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HENRY WILLEY,—A MEMOIR

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The subject of our sketch was born July 10, 1824, and died March 15, 1907. He was editor of a local newspaper, *The Standard,* at New Bedford, Massachusetts, from 1856 until 1900. In his vocation, he worked in obscurity. In his avocation, as a student of lichens, however, he was known to the botanists of two continents. Many American botanists are still living for whom he determined lichens a score of years or longer ago. He began the study of lichens about 1862 and continued until within a few years of the time of his death.

Mr. Willey started in a small way by collecting and determining the lichens of New Bedford and vicinity, with the encouragement and aid of Edward Tuckerman. This local work culminated in 1892, after thirty years of collecting and study, in "*An Enumeration of the Lichens Found in New Bedford, Massachusetts, and its Vicinity from 1862 to 1892.*" This publication embodies the results of the best piece of local work ever accomplished on American lichens, and would alone have given its author a place among students of lichens. The list contains nearly 500 species and subspecies, with copious notes. Probably very few of the lichens of the region, however minute or rare, escaped Mr. Willey's notice. Seventeen new species are described.

Mr. Willey's first publication on lichens appeared in 1867, and his last in 1898. Twenty-six papers constitute his contribution to lichen literature. Besides this, six lists of lichens have appeared

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in works by other botanists who gave Mr. Willey due credit for aid on lichens. It is not worth while to discuss each paper separately; but a list of his writings is given at the close of this sketch with explanatory notes on each paper, except in a few instances in which the title indicates content sufficiently well. The six papers which give Mr. Willey credit for work on lichens are appended.

The "*List of North American Lichens,*" which appeared in 1873, was helpful to many students two or three decades ago. This was a paper of 30 pages. Much more important and helpful was a 58-page paper, "*An Introduction to the Study of Lichens with a Supplement,*" which appeared in 1887. Probably every student of American lichens at that time possessed a copy of this work if he could get it. Mr. Willey's "*Synopsis of the Genus Arthonia,*" a 62-page monograph, may be regarded by some botanists as his best contribution to botany; but the writer's judgment is that the local work about New Bedford, culminating in 1892 in the rather short paper already considered above, is the best monument to his patience and skill as a student of lichens. Many botanists look with disfavor upon local floras; but this one is exceptional and represents a life work. On the other hand, Mr. Willey's synopsis of the Arthonias, though its author undoubtedly had an excellent knowledge of the genus, was in the nature of a compilation of existing descriptions and scarcely a critical work.

To Mr. Willey, we must give great credit for editing the second volume of Tuckerman's Synopsis after the death of its author. No one else could have done this important work so well as he who was, after the death of Tuckerman in 1886, the leading student of North American Lichens, and who was also especially fitted for the task by a thorough acquaintance with Tuckerman's methods and work.

Mr. Willey's output in new species was only 26. For his day, when little was known of our lichens, this seems like a small number; but the explanation is that Tuckerman was naming lichens by hundreds, and Mr. Willey's discoveries were named by this greatest American lichenist until his death. So all new species described by Mr. Willey were named after the death of

Tuckerman. The names are given in our list of writings at the close of this paper.

Excepting the Tuckerman herbarium, now at Harvard University, Mr. Willey's herbarium, now in the Smithsonian Institution at Washington, was the largest and most valuable private collection of lichens of his day, if indeed second to any other American lichen herbarium of any time, brought together by one person. The writer has had occasion to consult the Willey collection at Washington and knows personally of its great value. It contains about 10,000 specimens, many of them very rare and valuable.

Mr. Willey belonged to a type of students of lichens now extinct, or nearly so. He was never able to accept even the "dual hypothesis," but believed that the green or the blue-green cells were part of the lichen, just as chloroplasts are parts of higher plants. But some botanists of our day would be quite as much shocked to be told that both this view and the "dual hypothesis" are gone for those who have studied lichens in the light of modern morphology, physiology, mycology and cytology, and that all botanists will some day agree that the lichen is a fungus pure and simple, parasitic on an alga. Again, Mr. Willey, with others of his day, felt certain of the integrity of the group Lichenes. But this group is certain to be distributed generally among other Ascomycetes in the future. The accumulating evidence from the study of life histories of Ascomycetes leaves no alternative. It is not to the discredit of Mr. Willey that he held views very prevalent in his day. He did excellent work on lichens, but every person who studies these plants in our day should seriously consider their nature and proper classification.

Below is given the list of Mr. Willey's papers on lichens.

Willey, H. A fern new to our flora. Am. Nat. 1: 432, 433. 187. The paper also contains notes on 3 common lichens.

Willey, H. American lichenography. Proc. Essex Inst. 5: 191–196. 1867. Gives a fairly good list of publications on American lichens up to 1867.

Willey, H. Lichens under the microscope. Am. Nat. 4: 665–675. *f. 139–153.* 1871. A popular discussion of microscopic structure.

Willey, H. The spores of lichens. Am. Nat. 4: 720–724. 1871. A valuable discussion of the diagnostic value of number and size of spores.

Willey, H. A list of North American lichens. 1–30. New Bedford Mass., published by the author, 1873. A bare list of 808 species and subspecies of lichens. Also 2 genera and 3 species of pseudo-lichens.

Willey, H. Statistics and distribution of North American lichens. Bull. Buffalo Soc. Nat. Sci. 1: 161–167. 1874. Contains valuable information regarding distribution and relation to lichen species of other continents. Also mentions *Opegrapha antiqua* Lesq. (Haydens Report of 1873, p. 370) as the only fossil lichen described from our continent.

Willey, H. Illinois lichens. Bot. Gaz. 2: 77–79. 1877. A list of 113 lichens, followed by a few notes.

Willey, H. Lichens of Southern Illinois. Bot. Gaz. 3: 21, 22. 1878. A list of 61 lichens.

Willey, H. A new North American lichen. Bull. Torr. Club 8: 140, 141. 1881. Describes *Omphalodium hottentottum arizonicum* Tuck., with a general discussion of the species, named by Tuckerman and described by Willey.

Willey, H. Myco-lichens. Bull. Torr. Club 9: 6–8. 1882. A review of Minks' Symbolae Licheno-Mycologicae, and containing a list of 31 North American fungi considered to be lichens by Minks.

Willey, H. Theory of lichens. Bull. Torr. Club 9: 33. 1882. A note regarding the nature of lichens, giving Dr. J. Müller's views as confirmatory of Minks' theory of microgonidia.

Willey, H. *Parmelia furfuracea*, used in embalming. Bull. Torr. Club 9: 152. 1882.

Willey, H. First contribution to the knowledge of Kansas lichens. Bull. Washington Coll. Lab. Hist. 1: 16, 17. 1884. Lists 16 species with notes.

Willey, H. *Gyalecta lamprospora* Nyl. Bull. Torr. Club, 12: 61, 62. 1885. Gives Nylander's description of this new species.

Willey, H. New North American Arthoniae. Bull. Torr Club 12: 113–115. 1885. Gives descriptions of 12 species, but these are reproductions of Nylander's original descriptions in Flora, 1885.

Willey, H. Edward Tuckerman. Bot. Gaz. 11: 73–78. 1886. A sketch of Tuckerman's life, the first two pages of which are not written by Mr. Willey.

Willey, H. Lichens not previously reported from Kansas. Bull. Washburn Coll. Lab. Nat. Hist. 1: 176. 1886. Lists 5 species with notes regarding habitats.

Willey, H. An introduction to the study of lichens with a supplement. 1–58, *pl. 1–10*. New Bedford, E. Anthony & Sons. 1887.

Willey, H. Note on a new North American lichen. Bull. Torr Club 14: 134. 1887. A note on *Buellia catawbensis* Willey, which Nylander in a letter to H. A. Green had previously called *Dermatiscum porcelanum*.

Willey, H. Nylander's Synopsis. I. Bull. Torr. Club 14: 222. 1887. A review.

Willey, H. *Dermatiscum*. Bull. Torr. Club 14: 222. 1887. A note on *Dermatiscum catawbense* (Willey) Nyl.

Willey, H. Lichenotheca universalis. Bull. Torr. Club 14: 247–249. 1887. A review of Lojka's work of that name.

Willey, H. *Trypethelium heterochrous* (Mont.) Tuck. Bull. Torr. Club **15**: 170. 1888. A correction in form of the specific name.

Willey, H. A synopsis of the genus *Arthonia*. I–VII. 1–62. New Bedford, Mass. E. Anthony & Sons, 1890. Gives descriptions of about 350 species of the genus, of which *A. Austinii, A. viridicans, A. perminuta, A. Tuckermaniana, A. microspermella,* and *A. subdiffusa* are described as new from North America.

Willey, H. Enumeration of the lichens found in New Bedford, Mass., and its vicinity from 1862 to 1892. 1–29, 1892; E. Anthony & Sons, New Bedford, Mass. A list of almost 500 species and subspecies with copious notes and new or rare species described. New are: *Pyrenula compacta, Biatora papillariae, B. cladoniscum, B. gyalizella, B. terrena, B. rubidofusca, B. endocyanea, Opegrapha levidensis, O. cinerascens, Mycoporum difforme, Cyridula americana, C. macularis, C. rhoica, C. stigmaea, Coniocybe gracilescens, Verrucaria distans,* and *Pyrenula staurospora.*

Willey, H. Notes on some North American species of *Parmelia*. Bot. Gaz. **21**: 202–206. 1896. Notes on 18 species with the statement that the total number for North America is about 40.

Willey, H. *Parmelia molliuscula*. Rep. Mo. Bot. Gard. **9**: 160. 1898. Reports fruited specimen, collected in Colorado in 1877.

Arthur, J. C., Bailey, L. H., and Holway, E. W. D. Report of botanical work in Minnesota for the year 1886. Bull. Geol. and Nat. Hist. Surv. Minn. **3**: 1–56. 1887. A list of 36 lichens determined by Willey and F. L. Sargent, pp. 31 and 32.

Bennett, J. L. Plants of Rhode Island. Providence Franklin Society. I–XIII. 1–128. 1888. Lichens, pp. 20 to 25, 151 species. Revised by Willey.

Coulter, J. M. Botany, Sixth Am. Rep. U. S. Geol. Surv. 747–792. 1873. On pp. 790 to 792 is a list of 67 lichens with notes on habitat and distribution, determined by Willey. There are no new species, but 3 lichens are described briefly without specific names.

Porter, T. C., and Coulter, J. M. Synopsis of the flora of Colorado. U. S. Geol. and Geog. Surv. Territories. Misc. Pub. no. 4: 1–248. 1874. Lichens, pp. 161 to 163, by Willey, 54 species and subspecies. One *Lecanora* and 2 Verrucarias briefly described without specific name.

Rothrock, J. T. List of and notes upon the lichens collected by Dr. T. H. Bean in Alaska and the adjacent region in 1880. Proc. U. S. Nat. Mus. **7**: 1–9. 1884. List of 110 lichens with notes on locality, habitat, and structure, the work verified by Willey, who named and described as new *Biatora sibiriensis* from East Siberia.

Wolf, John, and Hall, Elihu. A list of the mosses, liverworts, and lichens of Illinois. Ill. State Lab. Nat. Hist, Bull. **2**: 18–35. 1878. The lichens were studied by Willey. See pages 27 to 34 for a list of 216 species and subspecies.

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STUDIES IN NORTH AMERICAN PERONOSPORALES—V.

A REVIEW OF THE GENUS PHYTOPHTHORA[1]

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(WITH PLATE 119, CONTAINING 5 FIGURES)

Within recent years our knowledge of this genus has been materially augmented by the appearance of a number of important papers. While it is not the present purpose to present a formal review of all these contributions, it seems worth while to make a general survey of the work which has been accomplished to see what advances have been made in our knowledge of this economically very important genus, as well as to take stock, to use a commercial term, with a view of learning what future lines of investigation promise most valuable results. Perhaps nothing has given greater incentive to the study of this genus or made the progress more rapid than the discovery that these fungi could be grown in pure culture. The first contribution to this subject was by Hecke (1898) who grew *P. infestans* on liquid media such as decoctions of plums, tomatoes, cherries, and potato leaves, but was unable to secure a growth on solid media. Later Clinton (1906) discovered that species of this genus could be grown on solid media other than vegetable plugs. Further discussion of this subject, however, is reserved for a later page. In order to best accomplish our object the various species will be taken up separately, reserving general subjects for the later part of the paper.

1. PHYTOPHTHORA PARASITICA Dastur

The most destructive of the few really serious diseases of the castor bean in India is due to this fungus which has been studied in great detail at Pusa (Dastur, 1913). Seedlings are attacked,

[1] Previous papers of this series have appeared in the Bulletin of the Torrey Botanical Club as follows: I. 34: 68–84; II. 34: 387–416; III. 35: 361–365; IV. 35: 543–554. 1907–'08.

causing them to "damp off," while on older plants the leaves suffer most. These are marked with concentrically ringed brown spots. The conidiophores, as is usual in this genus, may emerge either through the stomata or by rupturing the epidermis. The mycelium is both intercellular and intracellular, and often causing a blackening of the vascular bundles. The hyphae are at first quite slender, becoming thicker with age, so that they measure 3–9 μ in diameter. The haustoria are not numerous nor are they differentiated in appearance from young branches. The conidiophores are long and unbranched, usually 100–300 μ tall, but ranging 35–500 μ. The conidia are pyriform, distinctly papillate, 16–60 $\times$ 10–45 μ, and producing from 5 to 45 zoöspores. Intercalary conidia are also found in the cultures which resemble to a considerable extent similar bodies in *Pythium*, but germinating as do the typical conidia. "Varying temperature, alternate light and darkness and moisture are essential factors in the formation" of both conidia and zoöspores. In nature the fungus has been observed to produce conidia sparingly within the tissues of the host, a habit not observed in other species of the genus except *P. infestans*.

Conidial germination, according to the illustrations published, may be either of the typical *Phytophthora* type where each zoöspore escapes separately, or of the *Pythium* type where the entire mass of zoöspores escapes in a vescicle and are later liberated by its rupture. The zoöspores are not different from those of other members of the genus. Chlamydospores are also found in cultures.

The oöspores of this species are formed in the same manner as that described by Pethybridge for *P. erythroseptica*. Indeed the details of sexual reproduction were worked out on these two species simultaneously and independently by Dastur and Pethybridge, each arriving at the same conclusions, although priority of publication made the announcement of Pethybridge precede that of Dastur by several weeks. The most interesting point brought out by Dastur and not by Pethybridge is that the gametes may sometimes arise from the same "stalk" instead of from different ones. When they are on the same hypha the oögonium arises as an ingrowing cell at the base of the antheridium. The

antheridium has reached its full size, or almost so, before the oögonium appears. At the time of the maturity of the oögonium the protoplasm assumes the form of an oöspore and withdraws a little from the thin-walled oögonium, which at the same time becomes thicker walled, and develops a yellowish color. The oögonium measures 18–27 μ in diameter and the oöspores are 15–20 μ, with a thick, smooth, hyaline epispore.

A very interesting portion of the paper is that which deals with the chemical composition of the cell walls, which appears to be the only published account of such studies on a species of *Phytophthora*. It has been stated by previous writers that the cell-walls of the Peronosporales are composed of cellulose only in part, a substance designated callose being present and under certain conditions entirely replacing the cellulose. The tests failed entirely to show the presence of callose in the cell-walls either of the hyphae or the conidia of *P. parasitica*. The only exception to the pure cellulose reaction of the membranes being in the oögonium and oöspore where the inner walls are of a modified cellulose, while the outer walls appear to be of some pectic substance.

The pathogenic nature of the fungus was established by ample experiments. Observations were made which proved conclusively that healthy seedlings planted in the soil in which infected plants had grown within a few weeks past were attacked by the fungus. This is the first time that a species of *Phytophthora* has been positively shown to be able to live in the soil for even a short time although some of them have been strongly suspected of this habit.

Extensive cross-inoculation work with numerous hosts was carried out. Negative results were obtained on cacao, *Cereus, Colocasia, Cleome, Jasminum, Lepidium, Opuntia, Panax, Phaseolus,* and tobacco. Slight or indecisive infections were produced on Areca nuts and lilac. The following were well infected and frequently killed, *Clarkia, Fagopyrum, Gilia, Oenothera, Salpiglossis, Schizanthus, Solanum Melongena, S. Lycopersicum* and *S. tuberosum*. In a field where sesame was grown following castor beans the previous year the stray castor seedlings were attacked by the fungus and later a species of *Phytophthora* indis-

tinguishable from that of the castor bean attacked the sesame seedlings. Reciprocal inoculations proved the two fungi to be identical.

This very interesting fungus is certainly a species of *Phytophthora,* yet its conidial germination, the formation of globose, intercalary conidia, and its ability to live for a time in the soil all point to close relationship to *Pythium.*

2. PHYTOPHTHORA COLOCASIAE Racib.

This species was first described from Java on *Colocasia esculenta* (*C. antiquorum* Schott.) where it is widespread, but not considered of great economic importance. It has since been found in Formosa and over a wide range of teritory in India, where it causes sufficient damage to attract the attention of the workers at Pusa. The results of the studies of Butler and Kulkarni (1913) are highly suggestive of the possible extension of our knowledge of other species of the genus.

On account of the falling of the conidia with a portion of the conidiophore attached after the manner of the pedicel cell of *Basidiophora* and *Kawakamia* the species was transferred by Sawada (1911) to the later genus as *K. Colocasiae.* The fungus is certainly a *Phytophthora,* while *Kawakamia* is more closely related to *Basidiophora.*

Originally described as a leaf parasite, the investigations of Butler and Kulkarni show its activities to be much more widely extended. Not only are the leaf-blades and petioles, and even the inflorescence attacked, but "the parasite commonly reaches the corm and sets up a dry rot during storage," while badly infected plants may even fail to develop corms. This activity is quite suggestive of the tuber-rotting of the potato by *P. infestans.* In this connection it might be remarked that it is not at all impossible that the tuber-rot of *Colocasia* in which was ascribed by Massee to the activities of his *Peronospora trichomata* was in reality due to the attacks of *Phytophthora.*

Detailed studies were made of the fungus both on the host and in pure cultures. The hyphae are quite large (4–9 μ in diameter), with numerous simple, filamentose haustoria. On the aerial parts of the host the fungus is strictly intercellular, except for the

epidermal cells, while in the corm it becomes intracellular, entering both the storage cells and the vascular bundles. The short conidiophores emerge from the stomata. While they are usually simple and bear a single conidium, a second one may be borne in the typical cymose manner of *Phytophthora*. The conidia are quite large ($18–26 \times 30–60\,\mu$ or larger), somewhat pyriform, and more variable both in size and form than in most species of the genus. There is a broad blunt apical papilla.

When mature the conidium "contains a single vacuole of variable size. This is at first irregular and changes shape with the slow movements of the intersporangial protoplasm; then it becomes spherical and ultimately disappears suddenly. The protoplasm itself is at first coarsely granular and after the discharge of the vacuole it is almost homogeneous. About five minutes after the vacuole disappears, the first cleavage lines of the spore-origins become visible and the protoplasm contracts slightly so as to leave a clear space just inside the wall. Soon after, discharge occurs, in the manner so often described for *Phytophthora*, the spores being fully demarcated and provided with cilia before they emerge to the outside." "The zoöspores are more or less bean-shaped, one of the longer sides being convex and the other concave or plane. Each contains a small pulsating vacuole and two cilia arise near together from the concave or plane side, one projecting in front and the other behind while swimming. After swimming for some time they come to rest, round off, lose the cilia and become surrounded by a cellulose wall" (pp. 239–241). A cool temperature facilitates the discharge of the zoöspores. The production of conidia does not appear to be in any way affected by light.

On culture media chlamydospores are common. They vary in size from the diameter of the hypha to $30\,\mu$, and are quite distinct in appearance from the oöspores. As these also occur in *P. Faberi* and *P. parasitica* "it is not impossible that the bodies described as parthenogenic oöspores in several species are really chlamydospores."

Oöspores were produced in various cultures. They are of the same type as is described for *P. erythroseptica* and *P. parasitica*. The oögonia measure $24–35\,\mu$ and the oöspores $20–28\,\mu$. Their germination is unknown.

Infection experiments by Sawada on various species of *Colocasia* and *Alocasia* gave negative results except on forms of *C. antiquorum*. At Pusa infection experiments gave negative results on *Fagopyrum, Jasminum, Lepidium, Nicotiana, Oenothera, Opuntia, Ricinus, Salpiglossis, Schizanthus, Solanun Melongena*, and *Syringa*. A young potato plant showed a definite infection and a wounded tomato seedling gave a very indefinite infection. The only thoroughly successful inoculations were those on seedlings of *Gilia nivale*. The results are not surprising as an extention of hosts would naturally be looked for among the nearer relatives of the host, the Monocotyledons.

3. PHYTOPHTHORA ARECAE (Colem.) Pethyb.

This fungus, which was first described by Coleman (1910) as *P. omnivora Arecae*, is the cause of a very destructive disease of the Areca palm in southeastern India. It attacks the young nuts and the inflorescence covering them with a dense mycelial growth and causing the nuts to drop prematurely. Occasionally the entire tops of the trees are attacked, the hyphae even penetrating the vascular bundles.

The hyphae vary greatly in size up to 8–9 μ in diameter and bear a very few haustoria which are filiform and simple or rarely branched. More commonly there are no haustoria. The conidiophores are distinctly cymosely branched. The conidia vary considerably both in size and shape, measuring $20.6–45.4 \times 30.1–71.0 \mu$. It appears that light is an essential factor both in the production and the germination of the conidia. The zoöspores are about $11.3 \times 8 \mu$, with the anterior cilium measuring 20.7 μ in length and the posterior one 29 μ. The oöspores have not been observed in nature, but were produced on inoculated nuts in the laboratory. The antheridia and oögonia are described as being borne on separate branches of the same thread, the antheridium, at least in some cases, being formed first. The process of oöspore-formation is said to be similar to that described by De Bary for *P. Omnivora* and by Clinton for *P. Phaseoli*. While it is scarcely credible in the light of our present knowledge of the subject that this species really combines the processes of oöspore formation which are present in the species just mentioned, the

descriptions and figures given by Coleman indicate that this process is of the type which has been described for the two preceding species. The oöspores at maturity measure 23–38 μ in diameter.

Cross innoculation experiments were carried on with a number of plants either known to be hosts of some species of *Phytophthora,* or closely related to some known host. Zoöspores were used in each instance. Inoculations were made both with *P. Arecae* and *P. Faberi.* In addition to areca nuts and cacao pods the list included for both species of fungi members of the following genera; *Cereus, Clarkia, Oenothera, Salpiglossis, Schizanthus* and *Solanum.* "In the case of all the species experimented upon successful infection was accomplished with both fungi with the exception of *Solanum tuberosum.* It seems probable that seedlings of this plant also would be susceptible, but they were not available. In the case of *Solanum melongena* and *Lycopersicum esculentum* only seedlings proved susceptible. Inoculations of plants above 6 inches high were unsuccessful." Of three cacao pods inoculated one showed *Phytophthora* mycelium in the tissues, but did not produce conidia.

4. PHYTOPHTHORA PHASEOLI Thaxter

The first account of the oöspores of this species was given by Clinton (1906) in a paper which must rank as a classic in the literature of this genus as here are first detailed the results of the study of a species of *Phytophthora* in pure culture on agar. The oöspores occur in nature in the diseased pods and seeds of the host. They are smooth, with moderately thick walls, hyaline or light-yellowish in color, and 18–26 μ in diameter. The antheridia are hyaline, ovate to ovoid or irregular shaped bodies, which are usually applied to the base of the oögonium, and measure $8.5–11.5 \times 14–17\ \mu$. It appears that "the antheridia are not usually entirely differentiated on the thread until after contact with the oögonium." This, by the way, is quite suggestive of the description given by Blakeslee of the development of the progametes of heterothallic mucors.

In a later paper (Clinton, 1909) a more extended discussion of these phenomena is given. "In the development of the sexual

stage the antheridium is the first to appear, and is often apparently fully developed before there is much evidence of the oögonium. Whether or not the peculiar swellings spoken of earlier develop into antheridia as a result of contact with certain other threads or swellings, it is difficult to determine, but it seems most probable. This potential oögonial thread, with or without a swelling, becomes attached to the base of the antheridium and grows up along its surface toward the apex. Very often it can be seen when it has only partially covered the length of the antheridium. For a long time it was difficult to decide whether or not these threads did not actually penetrate the antheridium and grow through it, and we are not yet certain that this does not sometimes occur. Certainly the optical effect is frequently that of an internal thread with its apical walls very thin as compared with the side walls. In time, however, the oögonial thread reaches the top of the antheridium, and curving around its apex, begins to swell into the oögonium, which by this time is usually cut off from its basal thread by a septum."

To judge from the later work of Pethybridge (1913) and the illustrations from photographs which accompany the later paper by Clinton it appears that what this author really saw and described was the same type of oöspore formation as that recently described by Pethybridge and by Dastur, but that over-caution prevented him from making the proper interpretation of his observations.

5. PHYTOPHTHORA ERYTHROSEPTICA Pethyb.

The announcement by Pethybridge (1913) of this fungus is interesting as adding one more to the already long list of European diseases of the potato as well as including a second species of *Phytophthora* in the list. The fungus is doubly interesting as being the species for which was first described that peculiar method in oöspore formation which we must now consider typical of the genus *Phytophthora*.

So far as mycelial characters are concerned this species is not unlike other members of the genus. The conidia are similar to those of *P. infestans,* but larger and not so prominently papillate, although there is always a well-marked apical region with a

thicker and more transparent cell wall than is found on the remainder of the conidium. The conidia are ovate, or obpyriform due to subapical constriction, and average $20 \times 30\,\mu$. They are also very much crowded on the conidiophores which are not so highly developed as in *P. infestans,* nor are the conidia produced in such great numbers as in that species. Their germination was not noted.

The gametes are produced on separate hyphae, and at first are not well differentiated from other hyphal outgrowths. The antheridium, which is the first to appear, is a rounded or oval structure, borne laterally on the hypha from which it is soon separated by a septum. Sometimes, however, the antheridium is a true intercalary cell. In time the antheridium becomes filled with a very dense mass of granular protoplasm, apparently at the expense of the parent hypha as this becomes empty. The oögonial progamete arises in a similar manner, first appearing as a swollen knob-like body. If it comes in contact with the antheridium it grows in such a manner, as to penetrate it. The duration of this condition and the accompanying cytological phenomena have not been determined, but after a few hours, and apparently only at night, the oögonium bursts out of the antheridium and completes its development. The oögonial wall is usually thinner than that of the antheridium. As the oögonium attains its full size protoplasm ceases to migrate into it and its stalk becomes plugged, although no septum is formed. By this time the parent hypha is almost emptied of protoplasm. During the later stages of the development of the oögonium and just prior to the contraction of the protoplasm and its separation from the wall of the oögonium the contents of the antheridium begin to disappear, but in what manner was undetermined. At maturity the oösphere occupies the upper part of the oögonium, which is composed of the entire protoplasmic contents of the oösphere except small particles which adhere to the oögonial wall. The oösphere now begins to form a wall about itself, which utlimately is about $2\,\mu$ thick, smooth, and yellowish-brown in color. The mature oögonium is about $36\,\mu$ in diameter with a colorless wall which is less brittle than that of *P. infestans.* The oöspores are about 29–$30\,\mu$ in diameter, or considerably smaller than those of *P.*

infestans. The method of oöspore formation in this and related species is unique among the Phycomycetes.

In nature the fungus is known only from the peculiar pink-rot of potato tubers which it produces. On solid media like oat agar, potato stalks, bread, and carrots oöspores but no conidia were produced, while the reverse was true in regard to liquid media. Conidia were produced most abundantly on a watery extract of peat soil.

6. PHYTOPHTHORA INFESTANS (Mont.) De Bary

The present species has been a storm center ever since its advent into the scientific world, while its trouble-making possibilities have not yet been exhausted. At first a battle royal waged in western Europe as to the proper name of the species which was then referred to the genus *Botrytis.* So vigorous was this warfare, and so loosely were citations given that anyone who will successfully unravel the tangle in such a way as to effectively and equitably safeguard the honors due each of the contestants, disposing of their claims in a strictly impartial and judicial manner, and arriving at a designation of the species which will meet the requirements of any recognized code of nomenclature, he will have qualified as a real "nomenclatural expert."

The next violent discussion was precipitated by the announcement by Worthington G. Smith of the discovery of the oöspores of the fungus. The results of the ensuing discussion were humorously summarized by Smith who wrote that "the oöspores became a kind of a political subject—oöspores of *P. infestans* or not oöspores of *P. infestans?*" (Clinton, 1911 b). More recently the publications of Clinton and of Jones for a time bid fair to add to the interrogation "and if oöspores, whose?"

In America two names are conspicuously associated with the investigations of the morphology of this fungus. The first note concerning what may now be regarded as probably progametes of this species appeared as an abstract (Jones & Giddings, 1909) of a paper which was not published in full. This was followed in less than a year by the announcement from the same laboratory (Jones, 1909) of the finding of oöspore-like bodies of about 30 μ diameter, but with no evidence of antheridia. These were prob-

ably chlamydospores. A little more than a year elapsed before the announcement by Clinton (1911 a) that "absolutely perfect oögonia, antheridia and even oöspores have been obtained." In the more detailed account of the discovery which appeared in a few weeks (1911 b) the various steps in the development of the oöspore are not so carefully described as were those of *P. Phaseoli,* yet the descriptions of the two species are quite similar. The illustrations which are reproduced from photographs also bear out this statement as some of them show the basal antheridium pierced by the oögonium. While no one has observed an actual fertilization to take place in species of this genius Clinton notes that in case no antheridium were present the development of the oögonium would not pass beyond the differentiation of the oösphere. This certainly precludes the suggestion that the peculiar antheridia of this and other species of *Phytophthora* are functionless. The oögonia at maturity are 34–50 μ in diameter, with a thick, reddish-brown wall. The oöspores have a medium thick wall which is smooth and hyaline. They measure 24–35 μ in diameter. The experiments which were conducted to determine the factors which govern oöspore formation do not appear to have shed any considerable light on the subject.

The final report of the investigations of Jones and his associates (Jones, Giddings & Lutman, 1912) appeared soon after these papers by Clinton. This paper is a valuable contribution to our knowledge of *P. infestans* in all its aspects. His discussion of the bodies which he terms "resting spores" differs widely from the account given by Clinton. The bodies which are described by Jones are produced in masses large enough to be barely visible to the unaided eye on account of their brown color. "Much variation in structure, grooping, and mode of development of these bodies has been observed, partly due to variations in medium. Most of these bodies have clearly been abnormal developments, or at least have failed to reach normal maturity. Indeed, we doubt if any of them are to be regarded as strictly normal. Nevertheless, it seems worth while to figure and describe the more common or striking features observed" (p. 61). Figures 1 to 20 represent various bodies found in the earlier cultures. These are borne on enlarged hyphae and enclosed in what are interpreted as ex-

cessively gelatinized walls. The solid walls of these bodies are smooth, thick, and brown. Only in a single instance was anything observed which was analogous to the formation of an oösphere. One figure (no. 15) is especially interesting as it is very suggestive of the type of antheridia which have recently been described for several species of *Phytophthora*. It may be that the majority of these bodies are chlamydospores, a structure which is known for several species of the genus.

In the later cultures a very different type of resting spores were found. These are produced, as were the others, either terminally or intercalary, have a single cell-membrane which is thickly covered with spiny tubercles. These resting spores measured 20–33 μ in diameter. The wall has two or three spots which rupture easily and suggest germ pores. The younger stages of these bodies showed 30–50 nuclei. As no bodies corresponding to antheridia were found there is no proof that these bodies are sexual spores, nor is any such claim advanced for them. The exact status of these bodies appears not to have been exactly clear to the authors as the following quotation shows. "These spores have been found in nine different strains of *Phytophthora*. These nine strains were carried continuously in culture for over three years without anything occurring to throw suspicion on their purity. . . . This fact seems to rule out the occurrence of any ordinary type of saprophyte. . . . It is not believed possible that any admixture of saprophytic growth could have entered all cultures alike, much less persist without detection. The only suggestion that seems worthy of further consideration is that these resting spores might belong to a species parasitic upon *Phytophthora* as *Piptocephalis* is upon certain moulds. De Bary, indeed, suggests such a relation as possible between *Artotrogus hydnosporus* and *Pythium debaryanum*. It would seem to us almost impossible, however, that such a condition should occur in all nine cultures alike and persist without detection during so long a period and under such varied cultural conditions" (pp. 68, 69).

These conflicting observations left the question of oöspores of *P. infestans* in a most unsatisfactory condition until the appearance of a paper by Pethybridge and Murphy (1913) which presents evidence of a nature well calculated to set the matter at rest

permanently. These authors describe and figure oöspores similar to those of *P. erythroseptica,* but considerably larger, and agreeing in all respects with those described by Clinton. As the antheridia and oögonia were found to be of the same peculiar type as those of *P. erythroseptica* the authors are led to designate Clinton's "superimposed oögonial thread" as a defective observation of the material in hand. "No spores were observed resembling in any way the resting spores with protuberances on their walls figured by Jones, and recalling *Artotrogus hydnosporus.*" According to the observations of these authors when a culture once begins to form sexual organs," it continues to do so in the subsequent transfers without intermission; and although the relative abundance of these bodies may vary somewhat in the successive cultures, as a rule, the subsequent transfers from cultures rich in oögonia, become themselves in due time, also well provided with them." Several transfers covering a period of some fifteen months from the time of isolation appear to have been necessary for the formation of the oösporic habit, while about a week is necessary after making the transfer for the sexual organs to appear in the subculture. It is still an open question as to the conditions under which oöspores occur in nature, if they do so at all. A double oöspore is figured by these authors, and something approaching closely to such a condition is figured by Clinton.

Among the most interesting experiments recorded by Clinton (1911 b: 771–773) are those which concern the attempted hybridization of species. In these the first attempt was made with cultures of *P. infestans* and *P. Phaseoli,* the latter being the more vigorous species of the two and producing oöspores most abundantly. When these species were sown in the same culture "we obtained oögonia, usually only in the vicinity of the *P. infestans* colony, which were entirely different from the normal oögonia of *P. Phaseoli* that were produced abundantly all through the culture. These different *oögonia were of the P. infestans type,* which at that time we were just beginning to get in a small way in our pure cultures of *P. infestans* on oat juice agar, and they differed in that they usually *produced mature oöspores, and were far more abundant than we have ever obtained them in pure cultures of P. infestans.* . . . They also differ, perhaps, in not being so deeply

tinted, and there are some that seem to grade into *P. Phaseoli;* or at least are not very different from that species, as the oögonial walls are only slightly tinted and thickened." These hybrid oöspores were produced from the oögonia of *P. infestans* and the antheridia of *P. Phaseoli,* and measure about the same as the normal oöspores of *P. infestans.* The average measurements of *P. Phaseoli* are 22.5 μ and of *P. infestans* and the hybrids are about 30 μ. The evidence of the hybrid nature of these oöspores appears to be very strong. It would be interesting to know whether they produced fertile hybrids and if so if they are Mendelian or non Mendelian in their behavior.

Hybrids with *P. Cactorum* are also reported but are said to be much more difficult to produce. It is unfortunate that no host of this last species is given, as in the light of recent work on the genus it would be interesting indeed to know what strain of this species was used for the experiments.

Much attention is devoted by Jones to what may be called in a broad sense physiological problems, such as the relation of the fungus to its host, to culture media, to temperature, etc. Much of this data has been published previously and so need not be discussed at present except in a very general way. His observation (p. 28) concerning the production of conidia within the host is apparently the first reference to this habit in the genus *Phytophthora.* The subject of resistant varieties is discussed in considerable detail. "Well-marked and fixed differences exist among potato varieties in relative susceptibility to invasion by *Phytophthora infestans.* . . . These differences occur in foliage as well as in tuber. While foliage and tuber resistance generally go together, this relation is not invariable. The disease resistant quality is resident in large measure, and probably wholly, in the interior tissues of both leaf and tuber. In the tuber it is uniformly distributed throughout the flesh" (p. 83).

In discussing the hosts of this species reference is made to the list given by De Bary which includes "not only a number of other species of Solanaceae grown in gardens, but that he has observed it on one of the exotic species of the Scrophulariaceae, *Schizanthus grahami,* and that Berkeley has described a case where it occurred on another one of the same group, *Anthocercis*

viscosa, from New Holland." At the risk of appearing to be trite we may remark in passing that not only has there been advances made in mycology, but in other fields of botany as well in the past third of a century. Moreover some geographic names have also changed. New Holland is one of these, being labeled on our maps to-day New Guinea. As to the hosts in question both genera appear among the Scrophulariaceae in De Candole's Prodromus while in Engler and Prantl's Pflanzenfamilien they both appear under Solanaceae. In other words De Bary's taxonomy and geography were correct in his own day. This same reference to scrophulariaceous hosts is quoted by Lindau[2] and is given by Clinton as a reason for suspecting the validity of *P. Thalictri.*

Various theories have been advanced as to the means by which the present species maintains itself from year to year, one of them being that the fungus lives over in the soil or in the diseased tubers and débris from the crop. A paper by Stewart (1913) details some experiments on this question. Soil was taken from a field which had produced a crop of blighted potatoes. Diseased and partially decayed tubers and blighted stems were placed in the soil which was subsequently kept outdoors until spring, when it was planted with tubers procured from a blight-free field and treated with disinfectants. No infection occurred, nor could it be induced by painting the leaves with mud prepared from this soil and the diseased potatoes. The author considers his results inconclusive, but indicating that it is highly improbable that the disease persists in the soil over winter.

7. PHYTOPHTHORA THALICTRI Wilson & Davis

The oöspores of this species were found by Clinton (1909: 894) who says that "so far as could be determined, the antheridia and oögonia were developed from different mycelial threads." In the light of present knowledge this would indicate that these organs are of the same nature as those of *P. infestans*. The oögonia are reddish-brown, a little deeper tinted than those of *P. Phaseoli,* moderately thin walled, and measuring 25–33 μ in diameter. The oöspores are hyaline or very light colored, with medium thick,

[2] Sorauer. Pflanzenhr. ed III. 2: 140. 1908.

smooth wall, and measuring 18.5–25 μ in diameter. "Those seen by the writer," says Clinton, "did not differ materially from the oöspores of *P. Phaseoli,* so that we may expect those of *P. infestans,* when found, to be of similar character."

The fungus was not obtained in pure culture. Inoculations were made direct from the diseased leaves to the cut surface of potatoes and onto young tomato plants in the greenhouse. All failed, as did the attempts to produce the fungus on *Thalictrum* by inoculating it with a pure culture of *P. infestans,* which at the same time was able to infect potatoes. Concerning the identity of the present species and the results of his inoculations Clinton says, "since *P. Thalictri* resembles *P. infestans* so closely, the writer has thought that possibly they might not be distinct species. Worthington G. Smith (Diseases of Field and Garden Crops, pp. 275–6) gives a list of different hosts of *P. infestans* which include even two Scrophulariaceae. . . . While these experiments were probably not extended enough to speak positively, still they at least indicate that these fungi are distinct strains, if not distinct species" (p. 895). Personally the present writer regards these experiments as far more conclusive evidence of the distinctness of the two species in question than would the success of any of these inoculations have been of the identity of these fungi. The question which is raised concerning the hosts of *P. infestans* has been noted under that species.

The statement made by Clinton concerning the identity of *P. Thalictri* is misquoted by Dastur (p. 225) who speaks of "*P. Thalictri,* which Clinton suspects to be identical with *P. Phaseoli.*"

8. PHYTOPHTHORA FAGI (Hartig) Hartig

This fungus attacks the beech seedlings in Europe, often proving quite destructive. It first attacks the cotyledons, then spreads to other parts of the plant. A large number of other tree and herb seedlings are known to be subject to the attacks of a *Phytophthora* in Europe and it is not improbable that there is but a single species of the genus concerned in seedling diseases. This, however, has not been investigated in recent years. We are indebted to Himmelbaur for a careful comparative study of this

species and the demonstration of its validity. The results of these studies are discussed under *P. Cactorum.*

9. PHYTOPHTHORA CACTORUM (Lebert & Cohn) Schröt.

This species was originally described from diseased cacti in Europe and was later included along with other forms by De Bary in his *Phytophthora omnivora.*

Comparative studies were made by Himmelbaur (1911) on three forms which might well be included in De Bary's species. They were designated *P. Cactorum, P. Fagi,* and *P. Syringae.* The cultures of *P. Cactorum* were obtained from *Phyllocactus* at Dahlem. As a result of his inoculation experiments with these fungi on three species of cacti he concludes that inoculation experiments are of very little value in delimiting species. However the results of his inoculations, which he presents in tabulated form, are quite interesting so they are quoted in their entirity.

Host	Macroscopic			Microscopic		
	Cactorum	Fagi	Syringae	Cactorum	Fagi	Syringae
Echinopsis Eyriesii	Much affected	Much affected	± Slight infection	Very numerous oöspores	Very numerous oöspores	Numerous oöspores
Cereus tephracanthus	± Slight infection	± Slight infection	Slight infection	Numerous oöspores	Numerous oöspores	Few oöspores
Cereus Martianus	± Slight infection	Slight infection	± Slight infection	Numerous oöspores	Few oöspores	Numerous oöspores

All three forms were grown in Erlenmeyer flasks on sterilized carrots and in Petri dishes on various media. *P. Cactorum* made the most vigorous growth while *P. Syringae* was the weakest. He considers these forms all closely related but morphologically distinguishable both by conidial and oösporic characters as well as by the mycelium. He also expresses the opinion that *Peronospora Sempervivi* Schenk is identical with *Phytophthora Cactorum.* The results of his morphological studies are given in tabular form for ready comparison.

P. Syringae	*P. Fagi*	*P. Cactorum*
Mycelium:		
Hyphae slender, regular, intercellular, in culture submerged, apically monopodially much branched.	Slender, regular, intercellular or intracellular, in culture both aerial and submerged, apically scantily monopodially branched.	Very irregular in form, in culture both aerial and submerged, somewhat irregularly branched.
Haustoria simple or ganglionate and digately branched, cylindric.	Simple or branched, cylindric, or apically enlarged irregularly.	None.
Conidiophores sympodially branched and thickened below the conidia.	Sympodially much branched and thickened below the conidia.	Not typical sympodial in branching, conidia often borne in clusters.
Conidia elongate ovate, papillate, apex thick walled, produced tardily, size $40-74 \times 30-32\,\mu$.	More or less regularly ovate, papillate, produced abundantly, size $30-40 \times 15-30\,\mu$.	Roundish to ovate, very noticeably papillate, very variable in shape and size.
Oöspores:		
Oögonia globoid, intercallary, seen only in water cultures.	Pyriform, rounded at base, intercallary, seen in water and agar cultures.	Globoid, apical, seen in both water and agar cultures.
Antheridia borne near the oögonium, tube not seen, relation to oögonium indefinite.	Borne near the oögonium, tube present, applied basally.	Borne near the oögonium, rarely seen in water cultures, applied laterally.
Oöspore with medium thick, smooth, yellow wall, size $30\,\mu$.	With medium thick, smooth, yellow wall, size $20-30\,\mu$.	With medium thick, smooth, brown wall, size $30-45\,\mu$.

As a result of this comparative study it is very evident that these three forms are distinct species. The next question to present itself is that of the identity of the form which De Bary studied and named *P. omnivora*. From the evidence presented by De Bary in his paper Himmelbaur is inclined to the belief that the form was at least similar to *P. Fagi*, if not identical with it.

In old agar cultures which had begun to degenerate forms appear which are suggestive of *Vaucheria*, from which the author concludes that the genus *Phytophthora* may represent a degenerate state of *Vaucheria*.

The phenomenon of zonation in cultures was studied and the conclusion reached that it is due to variation in temperature.

10. PHYTOPHTHORA SYRINGAE (Klebh.) Klebh.

This fungus has been studied by three investigators who agree as to its morphology. Klebahn (1909) published a comprehen-

sive study of the fungus, including many inoculation experiments to determine its possible host limitations. He was able to secure an abundant infection with the production of oöspores on *Syringa persica, Lygustrum vulgare, Jasminum nudiflorum, Forsythia viridissima* and *Crataegus oxycantha,* while the twigs were killed on *Pirus communis* and *Prunus cerasus* without the formation of oöspores. Indifferent infection was obtained on species of *Acer, Aesculus, Alnus, Corylus, Quercus, Tilia, Pirus, Malus* and *Prunus domestica.* Complete failure was recorded for *Azalia, Betula, Carpinus, Fagus, Fraxinus, Juglans, Philadelphus, Plantanus, Salix, Sorbus, Erica* and *Calluna.* While the infection of the pear would at first sight indicate a possibility of the identity of *P. Syringae* with the species reported on pomaceous fruits, but the failure to infect the apple makes the probability of the identity of the two entirely out of the question.

The morphological characters of the species are included in the summary of the work of Himmelbaur under *P. Cactorum.* The fungus has recently been found in Holland, where it was carefully studied, especially from the standpoint of its economic importance, by Schoevers (1913), whose observations on the morphology of the fungus and its effect upon its host are in accord with the preceding papers. The statement is made that the conidia are unknown in nature. It is, therefore, interesting to note that almost thirty years earlier than any of these papers Berkeley (1881) described a fungus from the leaves of the lilac in Scotland which caused a blackening of the host similar to that caused by *P. infestans* on the foliage of the potato. The opinion was expressed that the two fungi were very closely related, although the lilac inhabiting species was christened *Ovularia Syringae.* In a subsequent paper Smith (1883) described bodies which he termed resting spores from decaying leaves, but his notes are insufficient to indicate the exact nature of the bodies which he found. A third note by the discoverer of the fungus (Wilson, 1886) describes in a somewhat fantastic manner the germination of the conidia by the formation of zoöspores. The fungus appears in Saccardo under Berkeley's name while the only figure cited is that which accompanied the original description. Apparently Saccardo saw nothing in this later sketch to indicate

that the species in question has other relationships than those indicated by its name. Indeed it is a true *Phytophthora* and apparently identical with *P. Syringae.*

The complete synonomy of the fungus then becomes, *Ovularia Syringae* Berk. (1881), *Phleophythora Syringae* Klebh. (1905), *Phytophthora Syringae* (Klebh.) Klebh. (1909). Here is a nomenclatural tangle which is not strictly amenable to the rule of priority. The oldest name of the species is that given it by Berkeley, yet if *Ovularia Syringae* were to be transferred to *Phytophthora* the combination would be untenable as there is already an older *Phytophthora Syringae,* which is based on *Phleophythora Syringae,* a name which is untenable because it is antedated in the synonomy of the species. Perhaps this case comes under the "nomina conservenda" and so will not need to be renamed, but be allowed to carry the specific name which Klebahn gave it.

11. PHYTOPHTHORA NICOTIANAE Van Breda de Haan

Our information concerning this species is derived from the monographic treatment of the species by its author. It is a member of the cactorum group of species, *i. e.,* its antheridium is of the normal type for the Oömycetes. So far it has been recorded only from the East Indies.

13. PHYTOPHTHORA FABERI Maub.

The literature of this species is quite extensive, yet there are a number of points concerning its life history which are far from clear. In the earlier papers the species is referred to as *P. omnivora* De Bary. Perhaps the first careful morphological study of the fungus was that of von Faber (1910) who obtained his material from Kamerun on cacao pods. He considers the fungus distinct from *P. omnivora,* but quite similar to that species. He describes the mycelium as being provided with haustoria and being both intercellular and intracellular, in extreme cases penetrating the seeds, but usually confined to the pods. The conidiophores are 150–200 μ high, bearing one or two conidia, which average $25 \times 30\,\mu$ or rarely as large as $42 \times 80\,\mu$. The

zoöspores are very numerous, as many as twenty issuing from a single conidium. The oöspores were found in abundance, throughout the infected tissue, but no trace of either antheridia or oögonia. As subsequent investigators have also failed to find the gametes it is now usually conceded that these bodies are in reality chlamydospores. The fungus is considered by von Faber to be coextensive in distribution with the cacao, although epidemic outbreaks have been confined to the American tropics, to Ceylon, and to Kamerun. Apparently drawing on von Faber's account of the fungus for his data Maublanc named it *P. Faberi.*

Infection experiments were first reported by Rorer (1910 a, b) who proved that the pod-rot and the canker of cacao are both caused by the same fungus. He gives a detailed study of the pathology of the organism, concluding that the trunks become infected by the migration of the mycelium from the pods through the twigs. This work was confirmed in Ceylon by Petch (1910) who extended his experiments to the fruit-rot and canker of *Hevea*. He demonstrated the identity of these diseases. "On plantations of *Hevea* only 'canker' has not caused very much damage, but on mixed *Hevea* and cacao plantations it is decidedly more serious." The fungus evidently spreads from the one host to the other in the field.

The correctness of the results obtained by Rorer has been questioned by Essed (1912) who was unable to duplicate the work. He suggests that the trees used might have already been infected with the true cause of the canker, which he considers to be some species of *Lasidiplodia, Nectria* or *Spicaria*, or some other related form. He asks "Why should Mr. Rorer obtain results different from mine? Was it due to the difference between his mode of operation and mine? To be sure, he operated with full grown trees and I did so with seedlings; his trees were standing in the open field and my seedlings were raised and kept under rigorously sterile conditions." The statement of the case by Essed may contain the answer to his inquiry. It is well known that certain fungi attacking mature hosts will not attack the juvenile stage of the same host plant. The reverse is also true. Moreover the "rigorously sterile conditions" under which these experiments were made might have been so thorough that *Phytophthora* could not grow.

Further studies of the species were made by Coleman (1910), who found that in water cultures the conidiophores often bore as many as twenty conidia. Chlamydospores were produced in his cultures in abundance, but oöspores were absent. Extensive infection experiments were carried on in connection with those on *P. Arecae*, under which species they are detailed. In addition the cacao fungus was inoculated onto Areca nuts, obtaining a slight infection in one instance. He named the fungus *P. Theobromae* giving as its hosts, on the authority of Petch, *Theobroma Cacao*, *Hevea brasiliensis* and *Artocarpus incisa*. In a postscript to his article he notes that "since the above was written an article by Petch . . . has brought to my attention the fact that the cacao fungus has been already given the name of *Phytophthora Faberi*." In listing the species of the genus Pethybridge includes *P. Faberi* which is "possibly synonymous with *P. Theobromae*."

From the fact that this fungus is more destructive in the American tropics than elsewhere it is not impossible that this is its home. This is further borne out by the fact that in the West Indies it attacks a second species of *Theobroma*, while its two chief hosts are American in origin. Indeed the bread-fruit is the only well authenticated host of oriental origin, and on this its occurrence appears to be quite limited.

13. PHYTOPHTHORA OMNIVORA De Bary

All members of the genus *Phytophthora* which were not referable to *P. infestans* were collected together under this name by De Bary. So constituted the species included all those forms of the genus found on seedlings and succulents in Europe. Recent work has shown some of these forms to be morphologically distinct, so that it is now a question as to just how much, if any, of the original mass of material can remain under this name.

Since the time of De Bary various writers have added their mite to increase the confusion until to-day the species as usually recognized is indeed a "waste basket" into which is thrown any unidentified *Phytophthora*. Some of these have recently been removed and given their proper status as species, while others which have been adequately studied by their discoverers have

escaped a fate which might have been theirs had they fallen into other hands. The existing confusion lead Coleman (p. 620) to say that "it would appear that a careful revision of the species *Phytophthora omnivora* is needed and this seems particularly necessary for those fungi from outside of Europe which have been identified as this species." It is, however, today the European forms of the species which are in most need of a careful revision.

From time to time a rot of pome fruits has been noted from Europe and ascribed to this species. It was first reported by Osterwalder (1906) on apples in Switzerland. As inoculations on *Sempervivium tectorum* were successful it was referred to this species. A rot of pears in Belgium was recorded by Marchal (1908) and in Bohemia by Bubák (1910), both of whom also refer the fungus to the present species. More recently Osterwalder (1912*a*) has added the strawberry to the list of fruits attacked, recording a serious outbreak in Switzerland. The same author (Osterwalder, 1912*b*) records an attack upon young apple nursery stock in which some varieties had almost all the twigs killed. As these young trees grew adjoining the strawberry patch which was so seriously infected it was presumed that this was the source of infection. In all these cases both conidia and oöspores were produced in abundance. The figures and descriptions indicate that more than one species of *Phytophthora* may be concerned and that in all probability none of these outbreaks were really due to the species which is credited with the damage.

Another European record under the name of this species is also furnished by Osterwalder (1909) who found a *Phytophthora* attacking *Calceolaria*. To judge both by the host and the description this may be referable to *P. Cactorum* as now understood, but further information concerning the fungus on this host is highly desirable.

The nutmeg tree (*Myristica fragrans*) in Java suffers from attacks on its leaves and growing twigs by a fungus which Zimmermann (1907) has identified as "*Phytophthora* spec. (*Ph. omnivora* de Bary?)." The conidia are ovate, prominently papillate, with a portion of the conidiophore adhering as a pedicel, measuring $20–60 \times 17–30\,\mu$. The conidiophores are typical of the

genus. No oöspores were found. The pedicel adhering to the conidia suggests a relationship with *P. Colocasiae*, although it is a distinct species, and apparently quite dissimilar to the average run of the oriental species of the genus.

The latest addition to the list of pests referred to this species was first reported by Hori (1907) as attacking ginseng in Japan and in Ohio. Since that time it has been found to be a widespread pest in ginseng beds in the United States. This fungus is certainly incorrectly identified. It is described as having simple conidiophores measuring $95 \times 7\,\mu$ and emerging from the stomata. The conidio are elliptic to ovate, $30–50 \times 50–60\,\mu$, prominently papillate, and having a very short basal pedicel. The oöspores are thick walled, light brown in color, and measuring $26–28\,\mu$.

SPECIES INQUIRENDAE

Three additional members of the genus have found their way into literature, yet are of doubtful standing on account of their improper introduction. Mention is made by Gandara (1909) of a *P. Agaves* Villada on the mayguey in Mexico, but no description or figure is given of the fungus. *P. Jathropiae* Petersen has been distributed by the "Centralstelle für Pilzkulturen" but is as yet undescribed. An unnamed species of *Phytophthora* is mentioned by Möller (1901) as occuring on the "figs imported from Europe to Brazil" and at least locally causing considerable damage in gardens. The liminiform conidia are prominently papillate and measure $38–45 \times 100–200\,\mu$. The conidiophores are $100–200\,\mu$ high. The relationship of the fungus is quite obscure as the only species of the genus with which he appears to have been acquainted is *P. infestans*. The fungus may be an European export, in which case it is probably closely related to the other fruit-rotting forms.

CROSS INOCULATIONS

One of the most interesting results of the work on species of *Phytophthora* in the last four or five years is the peculiar and altogether unexpected outcome of the numerous cross-inoculation experiments. A comparison of the results published by the vari-

ous authors tends to throw decided doubt upon the value of this method of delimiting species in this genus, as practically any species of Spermatophyta which is in nature subject to the attacks of any *Phytophthora* is likely under laboratory conditions to be more or less severely attacked by almost any other species. Indeed some of the hosts recorded for various species of the genus are not known to harbor these fungi in nature. It would appear, then, that the parasitism of *Phytophthora* is of such a low order that it will not admit of their being differentiated into races as are certain of the Uredineae for example.

CULTURE MEDIA

Such a discussion as the present would scarcely be complete without a brief mention of the methods and media employed in the pure culture work discussed above. Some of these media are very simple in their nature, but often serving an important purpose in the life history studies on these fungi. Such media are vegetable plugs of various kinds, decoctions of fruits and even of peaty soil, and in the case of one investigator flies were used in distilled water.

The best success has been obtained from growing these fungi on agar made with grain or leguminous seeds as its chief food base. Of these peas, beans and oats have proven most efficient and satisfactory. Such culture media may be made by the following formula, the various seeds and grains remaining constant. Ground beans 40 grams, agar 15 grams, water 1 liter. Prepare in double boiler, or in the autoclave, filtering through absorbent cotton. In case of oats it is preferable to boil 100 grams of ground oats in a liter of water using a double boiler and cooking the oats for two or three hours. Strain and add the other ingredients and sterilize. Species of *Phytophthora* prefer a slightly acid medium (+ 5 to + 10 Fuller's scale).

Synthetic media have received considerable attention from a number of investigators as such media would give a basis of accurate physiological observations. So far this does not appear to have been over successful. The rather extensive series of experiments conducted by him have led Jones to conclude that

low osmotic pressure is necessary to the proper development of *P. infestans* and that it is "limited to certain combinations of chemicals as sources of carbon, nitrogen, and energy. The only really efficient single carrier of these which was found is asparagin, and the availability of this substance seems to be dependent upon the presence of other chemicals" (pp. 51, 52). His most successful formula is as follows: Potassium phosphate 0.25 gm., potassium chlorid 0.05 gm., potassium nitrate 0.5 gm., magnesium sulphate 0.1 gm., calcium carbonate 0.025 gm., asparagin 0.5 gm., water 1 liter.

In the course of his extensive studies on the germination of the conidia of *P. infestans* in relation to various substrata Garbowski (1913) devoted considerable attention to the subject of synthetic media with the result that he recommends Knop's solution with the addition of glucose (0.2 gm. to 50 c.c.).

TAXONOMIC CONSIDERATIONS

From the discussion of the various species of the genus it is evident that there are two distinct types of sexual organs present in species which have been referred to *Phytophthora*. When De Bary described the oöspore formation in *P. omnivora* his account showed nothing which did not agree with the process as we know it in *Peronospora*. Recent investigations have confirmed this on *P. Fagi, P. Cactorum,* and *P. Syringae,* while the description of *P. Nicotianae* indicates that it belongs to the same group of species. These species have been designated by Pethybridge as the *Cactorum-group*. In *P. Faberi* the sexual reproduction is unknown, while in the remaining species of the genus the sexual organs are of the peculiar type described by Pethybridge and by Dastur. The group of species producing this type of gametes has been called in like manner the *infestans-group*. Here we find a mode of sexual reproduction which is unique among the Phycomycetes. So distinct is this method of oöspore formation that Pethybridge proposes to separate the species which possess it into a new family, calling it *Phytophthoraceae*. While the remaining species are retained in the family *Peronosporaceae* under the generic name *Nozemia*. While the process of oögenesis is so poorly understood at present, yet it is apparent from the peculiar

type of gametes and the complete absence of periplasm in the oögonium that the family *Phytophthoraceae* may perhaps be considered as constituting the order *Phytophthorales*.

The name *Nozemia* for the *Cactorum-group* of species is entirely unnecessary, as one of the species included in this new genus is itself the type of a monotypic genus. When Klebahn first published an account of *P. Syringae* he had only the oöspores which he recognized as belonging to the *Peronosporales*, and in absence of conidia he described the fungus as *Phleophythora Syringae*. As the genus was founded on the sexual phase of a polymorphic fungus certainly there can be no objection to its validity forthcoming from an adherent of the European views on the nomenclature of such fungi. Klebahn's name must, therefore, take the precedence, with the following species: 1. **Phleophythora Syringae** Klebh. (*Phytophthora Syringae* Klebh.), 2. **P. Fagi** (Hartig) n. nom. (*Phytophthora Fagi* Hartig), 3. **P. Cactorum** (Lebert & Cohn) n. nom. (*Peronospora Cactorum* Lebert & Cohn, *Phytophthora Cactorum* Schröter), 4. **P. Nicotianae** (Van Breda de Haan) n. nom. (*Phytophthora Nicotianae* Van Breda de Haan).

P. Faberi on account of its imperfectly known life history cannot be definitely assigned to a genus, so it may well remain as at present placed. As *P. omnivora* is here recognized as an aggregate of undetermined affinity it need be considered no further.

NEW BRUNSWICK,
NEW JERSEY.

BIBLIOGRAPHY

Berkeley, M. J.
1881. Lilac fungus.—Gard. Chron. II. **16**: 665. *f. 135.*

Bubák, F.
1910. Die Phytophthorafäule der Birnen im Böhmen.—Zeitschr. Pflanzenkr. **20**: 256–261. *pl. 4 + f. 1, 2.*

Butler, E. J. & Kulkarni, G. S.
1913. Colocasia blight caused by *Phytophthora Colocasiae* Rac.—Bot. Mem. Dept. Agr. India **5**: 233–261. *pl. 1–4.*

Clinton, G. P.
1906. Downey mildew, *Phytophthora Phaseoli* Thaxt., of lima bean.—Rept. Connecticut Agr. Expt. Sta. **1905**: 278–303. *pl. 20–22.*

Clinton, G. P.

1909. Artificial cultures of *Phytophthora,* with special reference to oöspores. —Rept. Connecticut Agr. Expt. Sta. **1907–08**: 891–907. *pl. 71–75.*

1911 *a.* Oöspores of potato blight.—Science, n. s., **33**: 744–747.

1911 *b.* Oöspores of the potato blight, *Phytophthora infestans.*—Rept. Connecticut Agr. Expt. Sta. **1909–10**: 753–774. *pl. 38–40.*

Coleman, L. C.

1910. Diseases of the areca palm (*Areca Catechu* L.) I.—Koleroga or rot disease.—Ann. Myc. **8**: 591–626. *pl. 7–9 + f. 1–3.*

Coleman, L. C.

(Note.—This paper was reissued with new pagination and with additional illustrations as Myc. Bull. Dept. Agr. Mysore **2**: 1–92. *pl. 1–81 + f. 1–6.* 1910.)

Dastur, J. F.

1913. On *Phytopthtora parasitica* nov. spec. a new disease of the castor oil plant.—Bot. Mem. Dept. Agr. India **5**: 177–231. *pl. 1–10.*

Essed, E.

1912. Cacao canker.—West Indian Bull. **12**: 302–308.

Faber, F. C. von.

1909. Die Krankheiten und Parasiten des Kakaobaumes.—Arbeit. Kais. Biolog. Anstalt Land- u. Forstw. **7**: 193–351. *pl. 2, 3 + f. 1–51.*

Gandara, G.

1909. Nota acerca de los enfermadodes fungosas del maguey.—Mem. y Rev. Soc. Cient. Antonio Alzate **25**: 293–305.

Garbowski, L.

1913. Keimungsversuche mit Konidien von *Phytophthora infestans* de Bary. —Cent. Bakt. II. **36**: 500–508. *pl.*

Hecke, L.

1898. Untersuchungen über *Phytophthora infestans* De Bary, als Ursache der Kartoffelkrankheit.—Jour. f. Landw. **46**: 71–74. *pl. 1, 2.*

Himmelbaur, W.

1911. Zur Kenntnis der Phytophthoreen.—Mitth. Botan. Staatsinst. Hamburg **1910**: 39–61. *pl. + f. 1–14.*

Hori, S.

1907. A disease of Japanese ginseng caused by *Phytophthora Cactorum.*—Bull. Imp. Cent. Agr. Expt. Sta. Japan **1**[2]: 152–162. *pl. 27.*

Jones, L. R.

1909. Resting spores of the potato fungus (*Phytophthora infestans*).—Science, n. s., **30**: 813, 814.

Jones, L. R. & Giddings, N. J.

1909. Studies of the potato fungus, *Phytophthora infestans.*—Science, n. s., **29**: 271. (Abstract.)

Jones, L. R., Giddings, N. J. & Lutman, B. F.

1912. Investigations of the potato fungus, *Phytophthora infestans.*—U. S. Dept. Agric. Plant Indust. Bull. **245**: 3–100. *pl. 1–10 + f. 1–10.*

(Note—This paper was reprinted from the same plates in 1913 and reissued as Bull. Vermont Agr. Expt. Sta. 168. The two editions are in every way identical except that the colored plates are omitted from the Vermont edition.)

Klebahn, H.

1909. Krankheiten des Flieders, pp. 75. *f. 45.* Berlin.

Marchal, E.

1909. Sur une maladie nouvelle du poirier.—Bull. Soc. Roy. Bot. Belgique **45**: 343, 344.

Möller, A.

1901. Phycomyceten und Ascomyceten, in A. F. W. Schimper, Botanische Mittheilungen aus den Tropen. Pp. xii, 319. *pl. 11.* Jena.

Osterwalder, A.

1906. Die Phytophthorafäule beim Kernobst.—Cent. Bakt. II. **15**: 435–440.

1909. Unbekannte Krankheiten an Kulturpflanzen und deren Ursache.—Cent. Bakt. II. **25**: 260–270. *pl. 1, 2.*

1912 *a.* Die Phytophthora-fäule die Erdbeeren.—Landwirt. Jahrb. Schweiz. **19**: 320, 321.

1912 *b.* Das Absterben von Veredlungen, versucht durch *Phytophthora.*—Landw. Jahrb. Schweiz. **19**: 321, 322.

Petch, T.

1910. Cacao and Hevea canker.—Cirs. and Agr. Jour. Royal Bot. Gard. Ceylon **5**: 143–180.

Pethybridge, G. H.

1913. On the rotting of potato tubers by a new species of *Phytophthora* having a method of sexual reproduction hitherto undescribed.—Sci. Proc. Royal Dublin Soc., n. s., **23**: 529–565. *pl. 42–44.*

Pethybridge, G. H., & Murphy, P. A.

1913. On pure cultures of *Phytophthora infestans* De Bary, and the development of oöspores.—Sci. Proc. Royal Dublin Soc., n. s. **13**: 566–588. *pl. 45, 46.*

Rorer, J. B.

1910 *a.* The relation of black rot of cacao pods to the canker of cacao trees.—Bull. Trinidad Dept. Agric. **9**: 38.

1910 *b.* Pod rot, canker, and chupon wilt of cacao caused by *Phytophthora* sp.—Bull. Trinidad Dept. Agric. **9**: 79–103. *pl. 9–17.*
(Note—The reprint of this article is paged 1–24.)

Sawada, K.

1911. Infection of the taro.—Reprinted from Special Reports of the Formosa Agr. Expt. Sta. (Japanese—quoted by Butler and Kulkarni.)

Schoevers, T. A. C.

1913. Eene voor Nederland nieuwe Seringenziekte, veroorzaakt door *Phytophthora Syringe* Klebahn.—Tijd. Plantenz. **19**: 41–64. *pl. 1, 2.*

Smith, W. G.

1883. Resting spores of the llilac fungus.—Gard. Chron. II. **20**: 439.

Stewart, F. C.

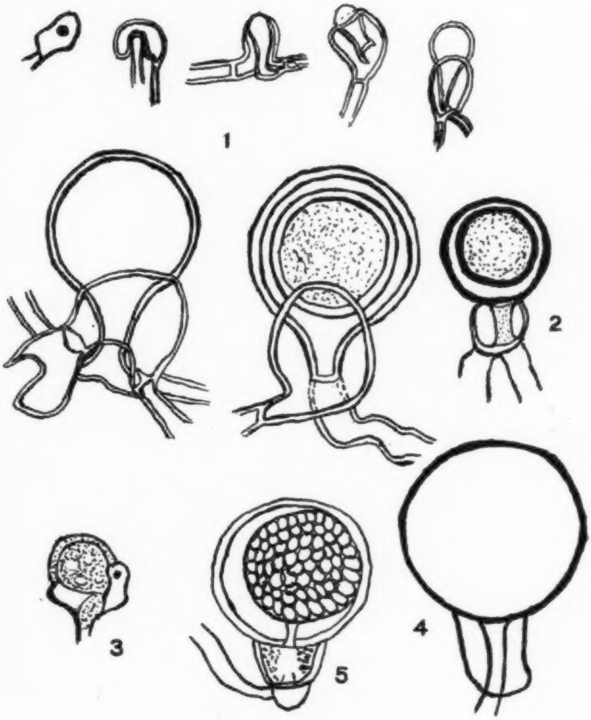
1913. The persistence of the potato late-blight in the soil.—Bull. New York State Agr. Expt. Sta. **367**: 357–361.

Wilson, A. S.

1886. Birth of an Ovularian zoöspore.—Gard. Chron. II. **26**: 815. *f. 159.*

Zimmermann, A.

1907. Ueber einige an tropischen Kulturpflanzen beobachtete Pilze—I.—Cent. Bakt. II. **7**: 101–106, 138–147. *f. 1–24.*



PHYTOPHTHORA

EXPLANATION OF PLATE CXIX

Fig. 1 *Phytophthora parasitica.* Seven stages in oögenesis. After Dastur.

Fig. 2. *Phytophthora Phaseoli.* Oöspore. After photograph by Clinton.

Fig. 3. *Phytophthora infestans.* Resting spore. After Jones, Giddings, and Lutman.

Fig. 4. *Phytophthora infestans.* Oöspore. After photograph by Clinton.

Fig. 5. *Phytophthora Arecae.* Oöspore. After Coleman.

A PRELIMINARY NOTE ON A NEW BARK DISEASE OF THE WHITE PINE

Arthur H. Graves

(With Plate 120, Containing 2 Figures)

In the spring of 1911, Mr. Herman de Fremery, a student at the Yale Forest School, called the attention of the writer to a disease which appeared to be killing the young white pines in a plantation at the Maltby Lakes, near New Haven, Connecticut.

Soon after this, a trip was made to the region in question. The stand consisted of *Pinus Strobus,* from 5 to 7 feet in height, planted 6 feet apart each way, and just about to commence the ninth year of growth. In one spot, several trees were seen to be entirely dead, forming a blank of considerable area, on the margin of which others were found to be in various stages of the disease.

In cases where the disease had not progressed far, the most apparent outward sign of the trouble was a slight yellowish cast of the foliage, which, from its strong contrast to the normal bluish-green of the healthy trees, could be readily detected from a considerable distance. To all outward appearances, the trunk was sound, but a careful examination showed that the extreme basal portion, which was often more or less covered with old dead leaves and needles, was somewhat sunken and covered with the minute black pustules of some fungus. The bark here was entirely dead, and often at this point the trees were entirely girdled, the lesions extending sometimes 3 or 4 inches from the ground (Plate 120, fig. 2).

At the time, as an effort to determine whether the fungus was a true parasite, four inoculations were made in healthy trees. For this purpose, pieces of bark from the lesions on diseased trees were transferred to corresponding positions at the base of healthy trees where areas of healthy bark of similar size had been cut out. The edges of the patch of diseased bark thus inserted were covered with grafting wax to prevent drying out and contamination.

As far as can be ascertained, these inoculations were unsuccessful, for at the present date, *i. e.*, after the lapse of nearly three years, in three cases the wounds have healed at their edges. Unfortunately, the fourth tree has been lost sight of, but it is of course possible that it was one of the dead tiees which have recently been removed from the blank. Since the inoculations were made in the spring of the year, the season may have been unfavorable for the invasion of the fungus, for at this period of its most rapid growth the pine has naturally its greatest capacity for wound healing.

At the present time, the blank caused by the disease in the above mentioned locality is more or less circular, and about 30 feet in diameter. Thirty-one trees have died, and 7 more, here and there around the edge of the area, are dying, each one with the characteristic canker at its base (Plate 120, fig. 1). Of the dead trees, the youngest show eight years' growth, proving that they died in 1910. The disease may therefore have been present at least two or three years before this.

Recently, Professors Toumey and Hawley, of the Yale Forest School, have again directed the writer's attention to the disease. Professor Toumey states that he has recently observed it near Conway Lake, Conway Center, New Hampshire. Here, among wild white pines, he saw several diseased patches, in one or two instances a rod or more in diameter. The trees were all the way from 1 to 10 feet in height, and showed the characteristic constrictions at the base of the stem. Professor Hawley has also noticed the trouble in various plantations in Connecticut. Dr. W. E. Britton, of the Connecticut Agricultural Experiment Station, says that he has seen it, or something very similar, on a plantation near Middletown, Conn. We understand that the same disease has also been reported as occurring in the State of New York.

Dr. G. P. Clinton,[1] in his report of Connecticut plant diseases for 1911–12, notes a trouble which is evidently the same. Speaking of it as a "stem canker," he states that some of the specimens have the aspect of being attacked by a parasitic fungus. He has found a *Phoma* fruiting on the dead area, and thinks that the trouble may be due to this.

[1] Clinton, G. P. Rept. Conn. Agr. Exp. Sta. **1912**: 354. *pl. 19a.* 1913.

On account of these various reports and inquiries concerning the disease, the writer has recently taken up its study in detail, one of the principal objects being to determine whether, as Clinton suggests may be the case, it is a trouble following winter or drought injury, or whether it is caused by a parasitic fungus. Connecticut plantations at East Haven, Mt. Carmel, and West Hartford have already been visited, and the disease, with all the symptoms as described above, has been found to be present at these places. Moreover, in all the plantations, blanks like the one described and figured here have been found, and these are being steadily enlarged by the death of trees around their borders.

In 1911, a fungus was isolated from the bark of the dying trees which was believed to be a species of *Fusicoccum*. The work was not followed up, however, and no inoculations with the pure cultures were made. In our recent work, nine fungi have been isolated from the bark of dying trees and several more from the bark of dead trees. Nevertheless, of these nine, the same species of *Fusicoccum* found earlier is of the most general occurrence. The bark of many trees is infested by this species alone, and it is also of importance to note that its fruiting bodies may be found in close proximity to the boundary between healthy and diseased bark. The plurilocular pycnidia, borne in a stroma, contain vast numbers of hyaline, cylindrical spores, usually with one end acute and the other blunt, and averaging $12 \times 2\,\mu$.

The disease resembles the "Einschnürungskrankheit" of the fir, described by Hartig[2] as killing branches of the host, and caused by *Phoma abietina* Hartig, which later became known as *Fusicoccum abietinum* (Hartig) Prill. and Delacr.[3] The spores of this, however, seem to differ in shape somewhat from those of our form.

Pure cultures have been made of all the fungi found on the dying trees, and inoculations with these species on healthy trees in the greenhouse are now in progress. The results of these, together with a more detailed account of the disease, will be published later.

[2] Hartig, Robert. Lehrbuch der Baumkrankheiten, ed. 2. p. 124. 1889.

[3] Prillieux, E., and Delacroix, G. Travaux du Laboratoire de Pathologie végétale, Bull. Soc. Myc. Fr. **6**: 176. 1890.

Fig. 1. PLANTATION OF WHITE PINE AFFECTED BY THE DISEASE

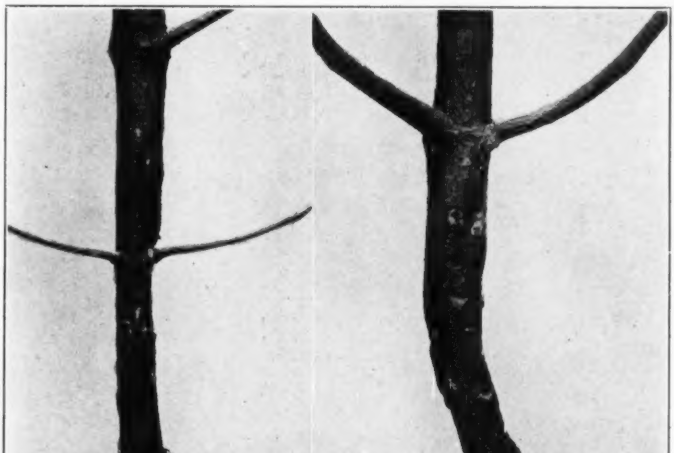


Fig. 2. YOUNG PINE TREES ATTACKED BY THE DISEASE

We take this opportunity, however, to warn owners of white pine plantations to be on the watch for this trouble. Since it is quite probable that it is of a parasitic nature, it is advisable to remove all diseased trees and burn them, or at least the parts of the stem that are affected with the disease, in order to prevent its further spread.

SHEFFIELD SCIENTIFIC SCHOOL OF YALE UNIVERSITY,
NEW HAVEN, CONN.

EXPLANATION OF PLATE CXX

Fig. 1. Photograph showing open area caused by the death of trees from the bark disease in a plantation of *Pinus Strobus* at Maltby Lakes, near New Haven, Conn. At the left, a dying tree, with yellowing leaves, and those of the latest growth much shortened: two trees entirely dead in the foreground at the right.

Fig. 2. Photograph of canker at base of stem of 7 year old *Pinus Strobus*. × 2/5.

NOTES ON A FEW ASHEVILLE FUNGI

H. C. Beardslee

(With Plate 121, Containing 2 Figures)

The occurrence of *Amanita porphyria* Fr. in the United States has been justly considered very doubtful. It has been reported sevaral times, but these reports have seemed open to grave doubts. Lloyd, in his paper on the Volvae, expressed the opinion that it does not occur in this country, and in Mycologia for March, 1913, the same opinion is expressed. In view of this uncertainty, it seems worth while to give the facts upon which my report of its occurrence was based.

In 1905, in company with Mr. Lloyd, I found this species in abundance in Sweden. As is well known, it is quite distinct in appearance, whatever may be thought of its validity as a species. Its brown pileus and the annulus, which forms a peculiar sooty ring on the stipe as the plant matures, at once distinguish it from all its relatives. We learned to recognize it at once.

Two years later, while collecting in Maine, I found what seemed to be the same plant. The pileus was the same color as those we had seen in Sweden and the same sooty ring was formed on the stipe. It was found in spruce woods near Harpswell, under conditions which were closely similar to those in the woods near Stockholm where we had observed it. When compared with Swedish specimens, no difference in microscopic structure could be found. It is, of course, easy to err in identifications of the fleshy fungi, as our literature amply shows, but I feel quite certain of the identity of these plants, especially as the species was already well known to me. I have never seen it in North Carolina. Perhaps, with the station accurately known, its occurrence may later be verified by some collector.

Two other species of *Amanita* mentioned in the March Mycologia may also be worth a brief mention.

Our *Amanita russuloides* belongs to a group of four species which have been described in Europe. *A. junquillea* Quél., *A.*

vernalis Gill., *A. Amici* Gill., and *A. adnata* W. Smith. The first three are French species, the last English. The feeling of many students is that these are all forms of one variable species. Boudier states in a letter that he considers *A. vernalis* and *A. Amici,* both of which he has studied, forms of *A. junquillea.*

Mr. Rea, whose excellent knowledge of the English species is well known, has carefully observed *A. adnata* and finds that the characters which were relied upon in separating *A. adnata* are inconstant. He lists it as a synonym for Quélet's species. It would seem that we need not trouble ourselves unduly in regard to this species.

Our *A. russuloides* is abundant in the southern mountains, where it may be collected all through the summer. At Asheville, the form is a rather better *A. adnata* than the others. It has uniformly no annulus, though farther to the north it seems to have one. I have carefully compared it with specimens from Boudier and have also submitted specimens and photographs to him and to Bresadola. Both agree in considering our plant *A. junquillea.* A comparison of the specimens leads to the same conclusion.

Amanita cothurnata Atkinson will doubtless need further study and comparison before its status is satisfactorily determined. At Asheville, it is one of the most abundant species and also one of the most attractive. Whether it should be considered a form of *A. pantherina* Fries is a question which would be decided partly by our ideas of specific distinction. Bresadola, to whom I judge it was submitted, states that he considers it distinct in its smaller size, white color, and especially its globose spores. Like Murrill, I have never seen typical *A. pantherina* in the United States. I found it common in Sweden and always with the same dark pileus, with which the white warts contrasted finely. At no time did we observe a white specimen. In size, there does not appear to be much difference, though possibly the American plant is on the average smaller. My suspicions as to the validity of our species came from the discovery that the spores are not globose in the fresh plant. A curious change in the spores takes place as specimens are dried. The spores, which are at first ellipsoid, lose their cell contents and become filled with a large globule as described by Atkinson, and at the same time become inflated and

globose. This change has been observed in some other species. With the spores of the fresh plants alike, the most valid grounds of separation seem to be removed. I believe it to be the American expression of *A. pantherina* Fries, though in this conclusion all will doubtless not agree.

If we have not yet arrived at an agreement in regard to the species of *Amanita,* it is not strange that some of our larger and more difficult genera are still more or less confused. The species of *Russula* are so numerous and so difficult of determination that it will be some time before they are all unraveled. At Asheville, this genus is represented by a large number of species. A few of these are of special interest and four of them are discussed here as a slight contribution to the study of this perplexing group.

RUSSULA SQUALIDA Peck

This species seems as yet not well understood in the United States. At Asheville, it is extremely variable. Peck describes it as dark-purple, often blackish at the disk. The forms here are so variable in color that they might easily be referred to different species. One form is pale-olive, with the margin almost white, one is a beautiful bright-purple, which approaches lavender, and another closely agrees with Peck's description. It is, however, so marked by such strong characters that it is easy to recognize it in all its disguises. The strong odor, which becomes very pronounced and disagreeable as it dries, distinguishes it at once. The stipe also quickly becomes yellow if it is lightly scraped, and then dark-colored. The fact that the lamellae discolor in drying assists materially in identifying dried specimens.

It seems, however, to have been overlooked that this is a comparatively well known European species. Romell, in his careful study of the Swedish species of *Russula,* distinguishes it, and it was described from his notes as *R. graveolens.* One who had seen Romell's plant under his guidance could not fail to recognize it at once as our own *R. squalida.* It has every characteristic of our American plant. In colors, it agrees well with Peck's description. Maire in his latest work considers it *R. xerampelina* Fr., in part.

RUSSULA MELIOLENS Quélet

This species is common at Asheville and was for several years a puzzle. It is not far from *R. alutacea* and *R. integra,* but is distinct from both. It is not unlikely that it has troubled others who have found it. It is a robust plant, with a peculiar faded red color, mild taste and cream-colored spores. As it dries, it develops a strong odor of new meal, which is very distinct. Its spores are different from those of any species with which it can be confused. They are subglobose and almost smooth. Under an enlargement of 150 diameters, they often seem entirely smooth. A good oil immersion of higher power shows the surface marked with very delicate warts with faint reticulating lines. This is so very unusual in the fragile species of *Russula* that it gives a very accurate means of identification. It is probable that the range of this species will be found to be extensive.

Russula rubescens sp. nov.

Pileus convex, finally expanded and depressed, 5–8 cm. broad; surface red, margin paler, fading with age, thin, striate; context mild to the taste; lamellae rather close, white, adnate, forked, especially at the base; spores pale-yellow, subglobose, 7–9 μ, rough, echinulate; cystidia large, numerous, 50–65 $\times$ 10–12 μ; stipe white, at length becoming cinereous without and within, often blackening with age or in drying, quickly becoming red and then black when wounded, stuffed, becoming hollow.

This species seems especially well marked. The reddening of the stipe when scraped is seen in certain members of the Compactae, but a red species which has this character is a novelty. It suggests in some ways *R. depallens* Fries, which seems to be a puzzle to European mycologists. It is believed by them, however, to be different from that species. As it grows, I find the stipe always becoming blackish within and without at the base.

RUSSULA ALBIDULA Peck

Pileus firm, soon depressed and somewhat infundibuliform, 4–10 cm. broad; surface pure-white, viscid when moist, margin even; context extremely acrid to the taste; lamellae white, becoming yellowish, rather narrow, unequal, decurrent, a few forking;

spores light-yellow, broadly ellipsoid, marked with strong, broken reticulations, 8–9 μ long; stipe pure-white, solid, firm, equal, 4–6 cm. long, 1.5–2 cm. thick.

This is one of the Furcatae. It is closer to *R. sanguinea* than any of the other species, but seems amply distinct from it. It is always pure-white and one of our firmest species as well as one of the most acrid. The spores of *R. sanguinea* are in all my specimens roughly echinulate, which is entirely different from those of this plant, which are adorned with strong raised lines forming a broken reticulation. I find it especially in pine woods during September and October. I have had it under observation for six years and find it remarkably constant.

ASHEVILLE SCHOOL,
ASHEVILLE, N. C.

EXPLANATION OF PLATE CXXI

Fig. 1. *Russula rubescens* Beardslee.
Fig. 2. *Russula albidula* Peck.

Fig. 1. RUSSULA RUBESCENS BEARDSLEE

Fig. 2. RUSSULA ALBIDULA Peck

AN ENEMY OF THE WESTERN RED CEDAR

William A. Murrill

(With Plate 122, Containing 2 Figures)

The species described below was first sent to me from Idaho by Mr. Weir. Since the description was drawn, Mr. Weir wrote me under date of December 17, 1913, as follows:

During the past season, the species has been abundantly collected throughout northern Idaho and Washington. It has been found to be of far greater importance in its relation to the decay of the western red cedar than my previous observations showed. Not only is it the principal fungus concerned in the basal decay of the living tree, but it continues the destruction of the heartwood and later of the sapwood after the tree has fallen and may extend along the entire tree, even attacking the bark. The chemical action of the mycelium on the wood results in a separation of the annual layers in the initial stages of decay, later developing a brown, friable rot quite characteristic and easily recognized. The damage caused by the fungus in the western red cedar is great enough to be made a special project for the coming field season.

Fomitiporia Weirii sp. nov.

Broadly effused, often extending many feet along the trunk, irregular, adnate, rather soft, of light weight, flexible when young, 3–10 mm. thick, margin rather thick, adnate or slightly seceding, undulate, lobed, or irregular, broadly sterile, ferruginous to fulvous, velvety-tomentose; context conspicuous, fulvous, punky, soft and flexible; hymenium plane or conformed to the substratum, fulvous-umbrinous, often with an avellaneous tint; tubes indistinctly 2–3 times stratified in older specimens, 2–4 mm. long each season, avellaneous within; mouths angular, stuffed when young, minute, about 6 to a mm., edges thin, entire; spores ellipsoid, smooth, hyaline, $5 \times 3\,\mu$; hyphae ferruginous; cystidia conic, tapering to a sharp point, not ventricose at the base, fulvous, filled with contents, sometimes strongly curved, $35–50 \times$

5–10 μ, the concolorous, tapering stalk often reaching 50 μ in length, but narrower than the projecting portion.

Type collected on a trunk of *Thuya plicata* at Priest River, Idaho, in the Kaniksu National Forest, in 1912, by James R. Weir. Common throughout the northwest, according to Mr. Weir, and confined to *Thuya plicata.* Younger stages would be referred to *Fuscoporia,* and the older stages sometimes have rather the appearance of "reviving" from year to year instead of being truly perennial, as is the case in most species of *Fomitiporia.* For the benefit of those using Saccardo's nomenclature, the species is here recombined as **Poria Weirii** Murrill.

NEW YORK BOTANICAL GARDEN.

EXPLANATION OF PLATE CXXII

Fig. 1. *Fomitiporia Weirii* as it appears normally, and also when reviving and a new layer of tubes is being formed.

Fig. 2. Initial stages in the decay caused by the above species, showing the separation of the annual rings of the host.

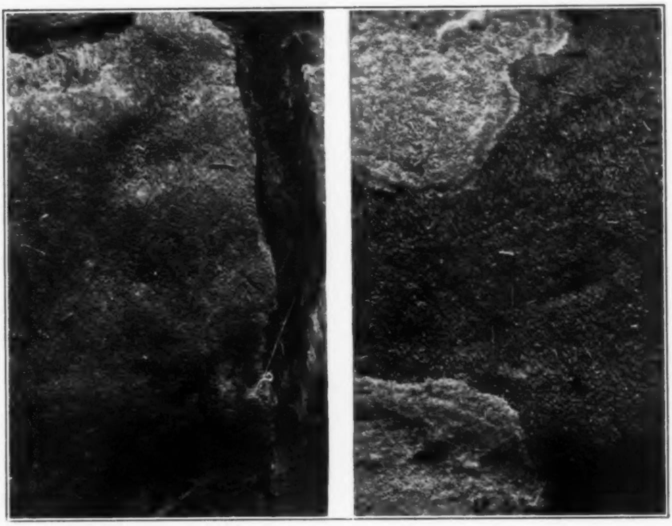


FIG. 1. SPOROPHORE OF FOMITIPORIA WEIRII MURRILL

FIG. 2. DECAY CAUSED BY FOMITIPORIA WEIRII MURRILL

NEWS AND NOTES

In the August number of *Phytopathology*, L. L. Harter describes *Plenodomus destruens,* a fungus causing "foot-rot" of sweet potato. A more complete account of the disease appeared in the *Journal of Agricultural Research* for December.

A recent paper by Hauch and Ravn on Oidium in the oak forests of Denmark describes the appearance and effects of the disease, the checking of growth and the lessening of resistance to cold, and suggests potassium sulfid solution as a remedy, but one that is unsuited to forest conditions by reason of the labor and expense involved.

Bulletin No. 355 of Cornell University treats of the apple scab disease, caused by the fungus *Venturia inaequalis* (Cooke) Winter. The paper which is by Errett Wallace contains in addition to a detailed study of the fungus, also a history of the distribution and economic importance of the disease. Also considerable space is devoted to a discussion of the means of controlling it.

In the June number of *Phytopathology*, J. J. Taubenhaus describes *Sclerotium bataticola,* a fungus causing "charcoal-rot" of sweet potato. This was formerly thought to be a state of *Sphaeronema fimbriata* (Ellis & Halst.) Sacc., but it has been proven conclusively by Taubenhaus that it is not. No other fruiting stage could be found for the fungus except the sclerotia, which are produced in large numbers.

Dr. F. D. Heald, of the Laboratory of Forest Pathology, Philadelphia, Pennsylvania, visited the Garden on February 4 and 5 to consult certain types of fungi in the Ellis Collection. He has

discovered some very interesting diseases of trees in connection with his work on the chestnut canker, and the results of his studies will shortly be published.

The January number of the *Journal of Heredity* contains three of the best popular articles yet published on the chestnut canker. Dr. Metcalf gives its history and characteristics, with a strong argument for careful inspection of future importations of nursery stock of all kinds; while Mr. Van Fleet and Dr. Morris tell of immune strains and resistant hybrids that may save the chestnut to horticulture if not to forestry.

The fifth annual meeting of the American Phytopathological Society was held at Atlanta, Georgia, from December 30, 1913, to January 3, 1914. The full program was completed with more than usual dispatch and opportunity was afforded for valuable discussion of the papers, owing to the method recently adopted of preparing a printed abstract of each paper in advance and presenting the papers in the form of abstracts only. As these have been widely distributed among mycologists already, they will not be repeated here.

A box of truffles was sent to the Garden last autumn for our examination, with a note requesting information regarding their food value. Later, the sender of this material made a visit here and stated that the truffles had been collected in the vicinity of New York through the aid of a trained dog imported from Italy. The specimens were filed away in the herbarium for later study. In November, a second package of these fungi was received which was said to have been collected in New Jersey. A microscopic examination of these plants showed them to be two different species. Later, a third collection of the plants was sent for examination, which collection was found to contain some examples of both of the species previously sent. These plants were of especial interest to us since they represent the only two specimens of the genus *Tuber* in our collection from America.

Three species of *Tuber* have been previously reported from the eastern United States, none of which accord well, so far as we can judge from the published accounts, with the two recently collected. The identity of the two recent collections has not been determined with certainty, but the specimens are kept for further study. The indications are that this genus may be well represented in the eastern United States.

In his work on underground fungi occurring in California, Harkness reports thirteen species of *Tuber*, but all of them are so rare as to be of little economic value. Harkness did not find any of the species of truffles usually eaten in Italy, but *Tuber californica* approaches very nearly to one of these Italian species. In addition to *Tuber*, a number of other genera of underground fungi contain edible species.

AGARICUS MUCIFER Berk. & Mont.

While examining recently the type specimens of fungi collected by Sullivant in Ohio and now preserved in the Montagne herbarium in Paris, I made a special effort to connect *Agaricus* (*Tricholoma*) *mucifer* Berk. & Mont. Syll. Crypt. 99. 1856 with some species of the genus at present known. The description of the species is as follows:

Pileus fleshy, convex to expanded, center depressed, 12 cm. broad; surface reddish-alutaceous, very viscid, glabrous; flesh incarnate or rosy; lamellae emarginate-decurrent, subconcolorous, white, red-spotted, changing to reddish on drying; spores oblong, apiculate, white; stipe stout, short, bulbous, fibrillose-striate, rufobadious, solid, 6 cm. long, 2 cm. thick at the apex, 3 cm. thick at the base; veil white, fibrillose, joined to margin of young pileus.

This description applies to a plant near *Tricholoma transmutans* or *Tricholoma Russula*. The type specimens are rather confusing. One packet, marked No. 274, has Sullivant's original number tied to the specimens. In this packet, there are two plants, one with bulbous stipe and purplish-red surface, which is evidently the type and is very near *Tricholoma Russula*, the other plant practically white and evidently Montagne's *Clitocybe*

leiphaemia, also collected by Sullivant in Ohio. The spores of the typical specimens are ovoid to ellipsoid, pointed at one end, smooth, hyaline, granular, $6–7 \times 3–4\,\mu$.

Another packet bearing the same number and named *A. mucifer* by Montagne contains still another species. There are in it two old and insect-eaten specimens with slender stipe, thin, crowded lamellae, and pale-purple surface, fading toward the margin. They resemble *Tricholoma Russula,* but are thinner and have a much longer stipe. The spores are broadly ellipsoid to globose, smooth, hyaline, granular, $7 \times 6–6.5\,\mu$. It is very evident that Montagne had difficulty in distinguishing species in the dried state and that the various species we have of the group represented by *Tricholoma Russula* and *Tricholoma transmutans* were confusing to him as they are to us. It is highly desirable that fresh specimens of this group be collected and carefully compared with Montagne's description of *A. mucifer.*

W. A. MURRILL.

INDEX TO AMERICAN MYCOLOGICAL LITERATURE

Banker, H. J. Type studies in the *Hydnaceae*—VI. The genera *Creolophus, Echinodontium, Gloiodon,* and *Hydnodon.* Mycologia **5**: 293–298. 25 N 1913.

Blodgett, F. H. College work in plant pathology. Plant World **16**: 304–314. N 1913.

Brooks, C. Some apple diseases and their treatment. New Hampshire Agr. Exp. Sta. Bull. 157: 3–32. *f. 1–30.* Ap 1912.

Burger, O. F. Lettuce drop. Florida Agr. Exp. Sta. Bull. 116: 27–32. *f. 1–3.* O 1913.

Sclerotinia libertiana.

Burlingham, G. S. The *Lactarieae* of the Pacific coast. Mycologia **5**: 305–311. 25 N 1913.

Includes *Russula crenulata, R. Murrillii,* and *R. bicolor,* spp. nov.

Cook, M. T. The diseases of tropical plants. v–xi + 1–317. *f. 1–85.* London, 1913.

Crabill, C. H. Studies on *Phyllosticta* and *Coniothyrium* occurring on apple foliage. Ann. Rep. Virginia Agr. Exp. Sta. **1911, 1912**: 95–115. *f. 18–33.* 1913.

Crabill, C. H. Production of secondary sporidia by *Gymnosporangium.* Phytopathology **3**: 282–284. *f. 1.* D 1913.

Davis, J. J. The introduction of a European pine rust into Wisconsin. Phytopathology **3**: 306, 307. D 1913.

Graff, P. W. Additions to the basidiomycetous flora of the Philippines. Philip. Jour. Sci. **8**: (Bot.) 299–309. *pl. 8–10.* N 1913.

Includes *Exidia lagunensis, Laschia philippinensis, Lentinus candidus, L. lagunensis, Volvaria pruinosa, Bovista Jonesii,* and *Naucoria manilensis,* spp. nov.

Hartley, C. The blights of coniferous nursery stock. U. S. Dept. Agr. Bull. 44: 1–21. 12 D 1913.

Heald, F. D., & Gardner, M. W. The relative prevalence of pycnospores and ascospores of the chestnut blight fungus during the winter. Phytopathology **3**: 296–305. *pl. 26–28.* D 1913.

Hesler, L. R. *Physalospora Cydoniae.* Phytopathology **3**: 290–295. *pl. 25* + *f. 1, 2.* D 1913.

Howe, R. H. The foliaceous and fruticose lichens of Concord, Massachusetts. With keys to all New England species. Proc. Thoreau Mus. Nat. Hist. **1**: 27–29. 24 S 1913.

Howe, R. H., Jr. Some Alaskan lichens. Bot. Gaz. **56**: 496–500. *f. 1, 2.* 18 D 1913.

Howe, R. H., Warburg, J. P., & Winsor, C. P. The Usneas of the World, 1752–1912. With citations, type localities, original descriptions and keys. Part I. North America. Proc. Thoreau Mus. Nat. Hist. **1**: 15–25. 10 My 1913.
Middlesex School, Concord, Massachusetts.

Johnston, J. R. The relation of cane cultivation to the control of fungous diseases. Sugar Producers' Assoc. Porto Rico Circ. 3: 3–12. O 1913.

Kellerman, K. F., McBeth, I. G., Scales, F. M., & Smith, N. R. Identification and classification of cellulose-dissolving Bacteria. Centralb. Bakt. Zweite Abt. **39**: 502–522. *pl. 1, 2.* 13 D 1913.

Kern, F. D. Notes on some puff-balls of Indiana. Proc. Indiana Acad. Sci. **1912**: 105–112. *f. 1–4.* 1913.

Lewis, C. E. Comparative studies of certain disease-producing species of *Fusarium.* Maine Agr. Exp. Sta. Bull. 219: 203–253. *f. 86–118.* O 1913.

Lloyd, C. G. Synopsis of the stipitate Stereums. 13–44. *f. 531–564.* Cincinnati. D 1913.

Long, W. H. A preliminary note on *Polyporus dryadeus* as a root parasite on the oak. Phytopathology **3**: 285–287. D 1913.

Ludwig, C. A. Fungous enemies of the sweet potato in Indiana. Proc. Indiana Acad. Sci. **1912**: 103, 104. 1913.

Macbride, T. H. Note on *Plowrightia morbosa.* Phytopathology **3**: 311, 312. 1913.

Melhus, I. E. The perennial mycelium of *Phytophthora infestans.* Centralb. Bakt. Zweite Abt. **39**: 482–488. *f. 1, 2.* 6 D 1913.

Merrill, G. K. New and otherwise interesting lichens from Vancouver Island and the Rocky Mountains. Ottawa Nat. **27**: 117–121. D 1913.

Includes *Lecanora atrosanguinea, Phlyctis speirea, Biatora Columbiana, Xylographa micrographa,* spp. nov.

M[orse], W. J. Appendix. [In Lewis, C. E. Comparative studies of certain disease-producing species of *Fusarium.*] Maine Agr. Exp. Sta. Bull. 219: 253–258. O 1913.

Murrill, W. A. A bad year for fleshy fungi. Mycologia **5**: 315, 316. 25 N 1913.

Murrill, W. A. Illustrations of fungi—XVI. Mycologia **5**: 287–292. *pl. 102–108.* 25 N 1913.

Coriolus versicolor, C. prolificans, Irpiciporus mollis, Poronidulus conchifer, Scutiger griseus, Grifola frondosa, Daedalea quercina, Elfvingia megaloma and *Fomes ungulatus.*

Murrill, W. A. Sterility in *Pholiota candicans* (Bull.) Schroet. Mycologia **5**: 314. *pl. 112.* 25 N 1913.

Reed, G. M. The powdery mildews—*Erysiphaceae.* Trans. Am. Mic. Soc. **32**: 219–258. *pl. 13–16.* O 1913.

Reed, H. S. The enzyme activities involved in certain fruit diseases. Ann. Rep. Virginia Agr. Exp. Sta. **1911, 1912**: 51–77. 1913.

Reed, H. S., & Cooley, J. S. The effect of *Gymnosporangium* on the transpiration of apple trees. Ann. Rep. Virginia Agr. Exp. Sta. **1911, 1912**: 82–90. *f. 16.* 1913.

Reed, H. S., & Cooley, J. S. The effect of the cedar rust upon the assimilation of carbon dioxide by apple leaves. Ann. Rep. Virginia Agr. Exp. Sta. **1911, 1912**: 91–94. *f. 17.* 1913.

Reed, H. S., & Crabill, C. H. Plant diseases in Virginia in the years 1911 and 1912. Ann. Rep. Virginia Agr. Exp. Sta. **1911, 1912**: 35–50. *f. 2–14.* 1913.

Reed, H. S., & Holmes, F. S. A study of the winter resistance of the uredospores of *Puccinia coronata* Cda. Ann. Rep. Virginia Agr. Exp. Sta. **1911, 1912**: 78–81. *f. 15.* 1913.

Saccardo, P. A. Notae mycologicae. Series XVII. Ann. Myc. **11**: 546–568. 31 D 1913.

Includes I. Fungi Mexicani, II. Fungi Canadenses, and III. Fungi Dakotenses. Twenty new American species are described.

Seaver, F. J. The genus *Pseudoplectania.* Mycologia **5**: 299–302. *pl. 109, 110.* 25 N 1913.

Sharp, L. T. Some bacteriological studies of old soils. Plant World **16**: 101–115. Ap 1913.

Smith, C. O. Black pit of lemon. Phytopathology **3**: 277–281. *pl. 24.* D 1913.

Bacterium citriputeale sp. nov.

Spaulding, P. Notes on *Cronartium Comptoniae,* II. Phytopathology **3**: 308–310. D 1913.

Stewart, V. B. The importance of the tarnished plant bug in the dissemination of fire blight in nursery stock. Phytopathology **3**: 273–276. *pl. 23.* D 1913.

Stopes, M. C. Catalogue of the mesozoic plants in the British Museum (Natural History). The cretaceous flora. Part I. Bibliography, algae and fungi. v–xxiii + 1–285. *pl. 1, 2 + f. 1–25.* London. 1913.

Theissen, F. Über einige Mikrothyriaceen. Ann. Myc. **11**: 493–511. *pl. 21 + f. 1–6.* 31 D 1913.

Includes *Chaetothyrium Rickianum, Thallochaete Ingae, Hysterostoma mystorum,* and *Lembosia modesta,* spp. nov. and *Amazonia, Thallochaete, Myxomyriangium* and *Hysterostoma,* gen. nov.

Van Hook, J. M. Indiana fungi—III. Proc. Indiana Acad. Sci. **1912**: 99–101. 1913.

Wolf, F. A. Another host for *Rhodochytrium.* Phytopathology **3**: 309. D 1913.

Wolf, F. A. Control of apple black-rot. Phytopathology **3**: 288, 289. D 1913.

Wolf, F. A. Internal aecia. Mycologia **5**: 303, 304. *pl. 111.* 25 N 1913.

Wolf, F. A. Some of the diseases of potatoes and cabbage. Proc. Alabama State Hort. Soc. **10**: 27–31. 1913.